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Effects of varying levels of dietary energy and crude protein on performance of layer-type cockerels

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Abstract

To study the effects of varying levels of dietary energy and crude protein on performance of layer-type cockerels, present study was undertaken. Experiment was carried out on a total number of 216 day-old layer-type cockerels up to 12th weeks of age. Total nine treatments rations (T₁ to T₉) were formulated with varying levels of metabolizable energy (ME) and crude protein (CP). T₁ ration contained 2800 Kcal ME/Kg and 20% CP; T₂ ration contained 3000 Kcal ME/Kg and 20% CP; T₃ ration contained 3200 Kcal ME/Kg and 20% CP; T₄ ration contained 2800 Kcal ME/Kg and 22% CP; T₅ ration contained 3000 Kcal ME/Kg and 22% CP; T₆ ration contained 3200 Kcal ME/Kg and 22% CP; T₇ ration contained 2800 Kcal ME/Kg and 24% CP; T₈ ration contained 3000Kcal ME/Kg and 24% CP as well as T₉ ration contained 3200 Kcal ME/Kg and 24% CP. Highest mean body weight was observed in at 12th week of age. Highest mean body weight gain was observed in birds fed diet with T₁ ration. Highest mean Feed Consumption was observed in birds fed diet with T₁ ration. Improved Feed Conversion Ratio Observed in T₄ Ration.

Keywords: Layer-type cockerels, dietary energy, crude protein, body weight gain, feed consumption, feed conversion ratio

Introduction

The experiment was conducted at Poultry Research Station, College of Veterinary Science & Animal Husbandry, Kamdhenu University, Anand, Gujarat. To study effects of varying levels of dietary energy and crude protein on juvenile growth performance and feed efficiency of layer-type cockerel. To study effects of varying levels of dietary energy and crude protein on Return Over Feed Cost of layer-type cockerel. A total of 230 day old male chicks (BV 300). The duration of experiment was 12 weeks (18 February 2022 to 13 May 2022) and was designed to study effects of varying levels of dietary energy and crude protein on performance of layer-type cockerels. A total number of 216 day-old layer-type cockerels, from a single hatch were used for the experiment. On arrival, day-old chicks were wing banded, weighed individually and distributed randomly to nine treatments. Each treatment group consisted of four replicates with six chicks in each. Feed was offered on a replicate basis. The chicks were brooded and reared up to 12 weeks of age using standard management practices. Total nine treatments rations (T₁ to T₉) were formulated with varying levels of metabolizable energy (ME) and crude protein (CP). T₁ rations contained 2800 Kcal ME/Kg and 20% CP; T₂ rations contained 3000 Kcal ME/Kg and 20% CP; T₃ rations contained 3200 Kcal ME/Kg and 20% CP; T₄ rations contained 2800 Kcal ME/Kg and 22% CP; T₅ rations contained 3000 Kcal ME/Kg and 22% CP; T₆ rations contained 3200 Kcal ME/Kg and 22% CP; T₇ rations contained 2800 Kcal ME/Kg and 24% CP; T₈ rations contained 3000Kcal ME/Kg and 24% CP as well as T₉ rations contained 3200 Kcal ME/Kg and 24% CP, respectively.

Materials and Methods

The birds were offered weighed quantity of feed daily according to their requirement and keeping in mind that the birds had access to sufficient feed at all times. The feed offered every time was weighed and recorded with all precautions to keep the wastage of feed at minimum level. Weighed quantity of different treatment diets were offered to chicks replicate wise during entire experimental period.

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On first day, feed was offered to chicks by sprinkling on papers and in plastic trays. From second day onwards, feed was offered in feeders only. Frequent stirring and mixing of feed in the feeder was done. Clean, fresh, wholesome drinking water was made available to all experimental birds *ad libitum* throughout the experimental period. Rice husk was used as litter material. It was spread evenly on the floor and was stirred occasionally to keep it dry. Strict biosecurity measures and standard medication programme were adopted. The birds were protected against various diseases by following vaccination schedule. Weekly body weight (g) was recorded at day-old (BW0), 1st (BW1), 2nd (BW2), 3rd (BW3), 4th (BW4), 5th (BW5), 6th (BW6), 7th (BW7), 8th (BW8), 9th (BW9), 10th (BW10), 11th (BW11) and 12th (BW12) week of age. Weekly body weight gain (g) was calculated as BWG0-1, BWG1-2, BWG2-3, BWG3-4, BWG4-5, BWG5-6, BWG6-7, BWG7-8, BWG8-9, BWG9-10, BWG10-11 and BWG11-12. The feed consumption was calculated by subtracting the feed left over from the total feed offered during the period of seven days. Feed consumption of 1st (FC1), 2nd (FC2), 3rd (FC3), 4th (FC4), 5th (FC5), 6th (FC6), 7th (FC7), 8th (FC8), 9th (FC9), 10th (FC10), 11th (FC11) and 12th (FC12) week was calculated. Feed consumption up to 4th week of age (TFC0-4), from 5th to 8th week of age (TFC5-8), from 9th to 12th week of age (TFC9-12) and up to 12th week of age (TFC0-12) was calculated. Feed conversion ratio (FCR) is the amount of feed consumed to produce one kilogram of live body weight and is an important tool to measure the feed conversion efficiency of birds. Total feed consumption and total body weight for each week were worked out replicate-wise for each treatment separately. Livability was calculated by recording mortality that occurs up to 12th week of age. Return Over Feed Cost (ROFC) of each treatment group was calculated after the end of the experiment. Cost of each treatment group was calculated and it was taken into consideration while calculating Return Over Feed Cost (ROFC). The data were analyzed using Completely Randomized Design as per Snedecor and Cochran (1994). Means of replicates under each treatment were considered for analysis.

Results and Discussion

The mean body weight (g) of birds at day old, 2nd, 3rd, 4th, 5th, 6th, 9th, 10th, 11th and 12th week of age did not differ significantly among treatment rations. At the 1st week of age, the mean body weight (g) of birds fed with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be 58.71 ±1.94, 64.43±0.48, 67.63±2.59, 63.21±0.74, 67.17±2.13, 63.42±0.74, 65.96±1.51, 65.79±1.79 and 66.46±1.90, respectively. The mean body weight of birds at 1st week of age fed diet with T₂, T₃, T₅, T₇, T₈ and T₉ rations was significantly ($p<0.05$) higher than birds fed with T₁ ration. Highest mean body weight at 1st week of age was observed in birds fed diet with T₃ ration followed by T₅, T₉, T₇, T₈, T₂, T₆, T₄ and T₁ rations. The mean body weight (g) of birds at 7th week of age fed with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be 489.63±21.44, 453.50±23.67, 452.30±20.21, 506.73±9.03, 508.40±6.52, 415.10±22.60, 510.48±10.42, 455.25±24.18 and 447.58±15.69, respectively.

The mean body weight of birds at 7th week of age fed diet with T₇ and T₅ rations was significantly ($p<0.05$) higher than birds fed with T₂, T₃, T₆, T₈ and T₉ rations. Highest

mean body weight at 7th week of age was observed in birds fed diet with T₇ ration followed by T₅, T₄, T₁, T₈, T₂, T₃, and T₉ and T₆ rations. The mean body weight (g) of birds at 8th week of age fed with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be 618.85±20.93, 568.20±30.55, 571.88±20.43, 626.15±5.27, 607.60±6.77, 524.70±26.86, 630.68±9.91, 574.48±28.21 and 570.88±21.39, respectively. The mean body weight of birds at 8th week of age fed diet with T₇ ration was significantly ($p<0.05$) higher than birds fed with T₆ ration. Highest mean body weight at 8th week of age was observed in birds fed diet with T₇ ration followed by T₄, T₁, T₅, T₈, T₃, T₉, T₂ and T₆ rations. At 12th week of age, the mean body weight (g) of birds fed diet with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be 903.08±21.83, 856.83±26.05, 862.30±20.28, 880.78±14.27, 838.60±13.07, 809.00±32.42, 863.90±19.78, 860.83±26.88 and 869.28±30.37, respectively. There were no significant differences in BW12 among all the treatment rations. However, highest mean body weight at 12th week of age was observed in birds fed diet with T₁ ration followed by T₄, T₉, T₃, T₇, T₂, T₈, T₅ and T₆ rations.

The weekly body weight gain (g), i.e., BWG1-2, BWG3-4, BWG4-5, BWG5-6, BWG7-8, BWG8-9, BWG10-11, BWG11-12 and overall experimental period (BWG0-12) of age did not differ significantly among treatment rations. The mean body weight gain (g) of birds during the whole experimental period (0-12 week of age) fed diet with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be 955.30±17.81, 905.70±29.88, 908.53±31.76, 927.65±18.52, 884.00±19.12, 855.44±28.35, 906.18±24.66, 901.59±24.55 and 916.54±26.56, respectively. There were no significant differences in BWG0-12 among all the treatment rations. However, highest mean body weight gain (BWG0-12) was observed in birds fed diet with T₁ ration followed by T₄, T₉, T₃, T₇, T₂, T₈, T₅ and T₆ rations.

The mean feed consumption (g/bird) of birds at day FC2, FC5, FC6, FC7, FC8, FC9, FC10, FC0-4, FC5-8 and overall experimental period (FC0-12) of age did not differ significantly among treatment rations. At 0-12 week of age, the mean feed consumption of birds fed diet with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be 2887.65±108.4, 2896.88±135.05, 2962.83±132.88, 2995.50±137.11, 2718.04±217.50, 2813.40±162.25, 2988.00±170.95, 2945.46±146.09 and 2914.76±90.42, respectively. The mean total feed consumption of birds at 0-12 week of age fed diet with different treatment rations did not differ significantly among each other. However, highest total feed consumption at 0-12 week of age was observed in birds fed diet with T₄ ration followed by T₇, T₉, T₃, T₂, T₈, T₁, T₆ and T₅ rations.

The feed conversion ratio calculated at the end of each week i.e., FCR0-1, FCR0-2, FCR0-3, FCR0-4, FCR0-5, FCR0-6, FCR0-7, FCR0-8, FCR0-9, FCR0-10, FCR0-11 and FCR0-12, respectively.

The feed conversion ratio of birds up to 12th week of age fed diet with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be 2.90±0.12, 3.07±0.11, 3.13±0.13, 3.09±0.03, 2.95±0.17, 3.14±0.03, 3.15±0.05, 3.12±0.09 and 3.05±0.08 respectively. The mean feed conversion ratio of birds (FCR0-12) fed diet with different rations did not differ significantly among treatment rations. However, improved feed conversion ratio (FCR0-12) was observed in T₁ followed by T₅, T₉, T₂, T₄, T₈, T₃, T₆ and T₇ rations.

Livability (%) of birds fed diet with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be 100, 100, 100, 100, 100, 100, 96.43, 100 and 100, respectively. During 4th week, one bird was died due to heat stress.

ROFC (Rs./bird) for birds fed diet with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ rations was found to be -66.05, -78.13, -90.35, -81.23, -82.23, -99.26, -98.89, -108.82 and -118.13,

respectively. Income from selling of birds (Rs./bird) for birds fed diet with T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉, rations was found to be 44.83, 42.54, 42.70, 43.58, 41.62, 40.33, 42.64, 42.39 and 43.08, respectively. The highest income from selling of birds (Rs./bird) was in the birds fed diet with T₁ ration followed by T₄, T₉, T₃, T₇, T₂, T₈, T₅ and T₆ rations.

Table 1: Experimental Diets (Treatment Details)

	Cockerel mash (0-12 week)								
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉
ME (Kcal/Kg)	2800	3000	3200	2800	3000	3200	2800	3000	3200
CP (%)	20.00	20.00	20.00	22.00	22.00	22.00	24.00	24.00	24.00
No. of replication	4	4	4	4	4	4	4	4	4
No. of birds/replication	6	6	6	6	6	6	6	6	6
Total no. of birds/treatment	24	24	24	24	24	24	24	24	24
Grand total of birds	216								

Table 2: Proportion of feed ingredients used for preparation of cockerel mash

Sr. No.	Ingredients	Cockerel mash (0-12 weeks)								
		T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉
		Qunt./100 kg	Qunt./100 kg	Qunt./100 kg	Qunt./100 kg	Qunt./100 kg	Qunt./100 kg	Qunt./100 kg	Qunt./100 kg	Qunt./100 kg
1	Maize	55.230	65.146	59.990	53.220	58.640	53.492	51.210	52.133	46.980
2	Soyabean DOC	27.740	30.290	31.190	33.740	35.800	36.690	39.750	41.310	42.210
3	Deoiled Rice Bran	13.150	0.000	0.000	9.228	0.000	0.000	5.299	0.000	0.000
4	Limestone powder	1.279	1.205	1.200	1.242	1.186	1.182	1.202	1.169	1.160
5	Vegetable oil	0.000	0.615	4.873	0.000	1.703	5.962	0.000	2.790	7.049
6	DCP	1.648	1.764	1.763	1.633	1.714	1.713	1.618	1.664	1.663
7	Vitamin premix	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
8	Trace minerals	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
9	Choline Cl (60%)	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
10	DL-Methionine	0.101	0.107	0.110	0.079	0.084	0.087	0.057	0.061	0.064
11	L-Lysine	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	Enzymes	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
13	Phytase	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
14	Salt	0.237	0.258	0.259	0.243	0.258	0.259	0.249	0.258	0.259
15	Soda bicarbonate	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
16	Liver tonic	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
17	Immunomodulators	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
18	Toxin Binder	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
19	Probiotic	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
20	Diclazuril 25%	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 3: Return Over Feed Cost (Rs./bird)

Particulars	Treatments								
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉
Feed consumption (Kg)	2.888	2.897	2.963	2.996	2.718	2.813	2.988	2.945	2.915
Cost of feed (Rs./Kg.)	38.40	41.66	44.91	41.67	45.65	49.62	47.37	51.34	55.31
Average body weight (g)	996.30	945.47	948.92	968.575	924.90	896.25	947.57	942.05	957.35
Cost of feed consumed (Rs./bird)	110.88	120.68	133.06	124.82	124.07	139.60	141.54	151.21	161.21
Income from selling of birds (Rs./bird) (@ 45 Rs./Kg. body weight)	44.83	42.54	42.70	43.58	41.62	40.33	42.64	42.39	43.08
ROFC (Rs./bird)	-66.05	-78.13	-90.35	-81.23	-82.23	-99.26	-98.89	-108.82	-118.13

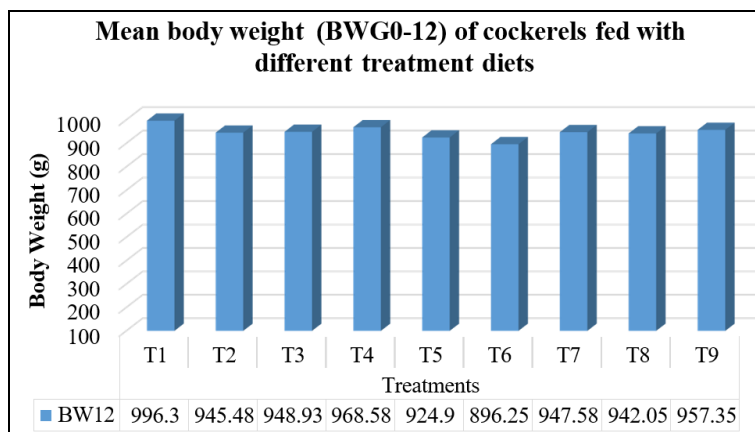


Fig 1: Mean body weight (BW12) of cockerels under different treatments

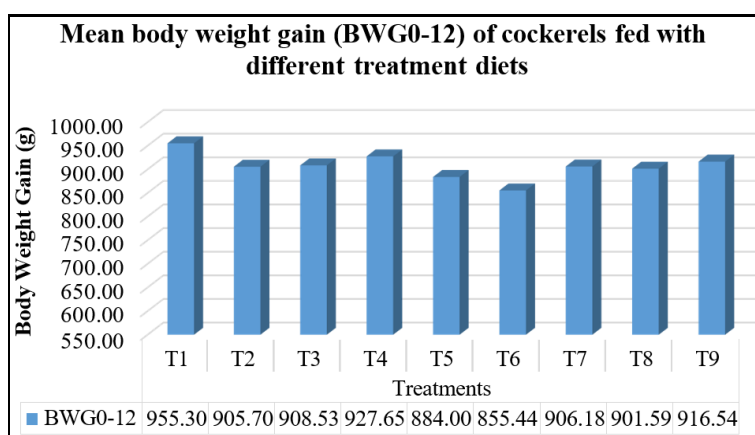


Fig 2: Mean body weight gain (BWG0-12) of cockerels under different treatments

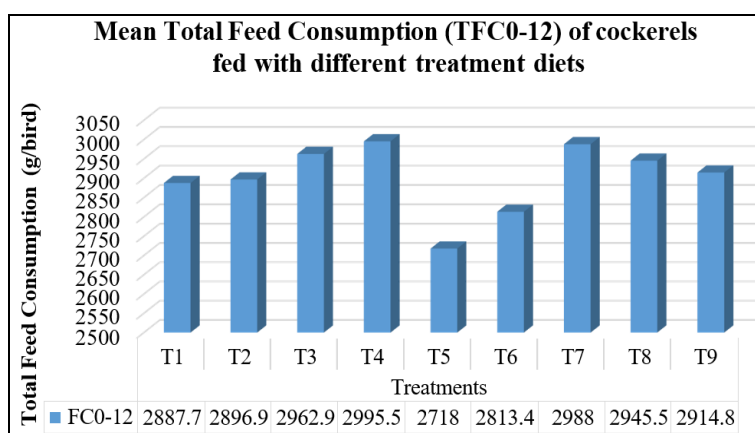


Fig 3: Mean Total feed consumption (FC0-12) of cockerels under different treatments

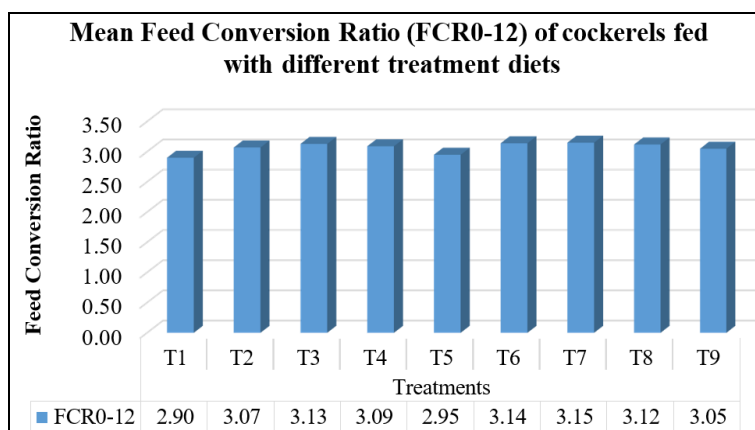


Fig 4: Mean Feed Conversion Ratio (FCR0-12) of cockerels under different treatments

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Conclusion

Layer-type cockerels fed diet T₁ containing 20% crude protein and 2800 kcal metabolizable energy/kg showed comparatively higher body weight, body weight gain, improved feed conversion ratio, lowest feed cost per bird, and highest income from bird sales up to 12 weeks of age, although differences among dietary treatments were not statistically significant. The lowest feed consumption was recorded in birds fed diet T₅ (22% crude protein and 3000 kcal metabolizable energy/kg), with no significant variation among treatments. Livability remained high across all treatments, ranging from 96.43% to 100%, indicating good health and management. Despite these performance parameters, Return Over Feed Cost (ROFC) was negative for all diets due to high feed costs and low market price of cockerels under the intensive deep-litter system. Thus, rearing layer-type cockerels under the present experimental conditions was not economically viable. Future studies should evaluate these parameters under backyard or low-input production systems to better assess economic feasibility.

References

1. Basic Animal Husbandry Statistics. Basic animal husbandry statistics. AHS Series 13. New Delhi: Department of Animal Husbandry, Dairying and Fisheries, Government of India; 2020.
2. Bertechini AG, Mazzuco H, Rodrigues EC, Ramos EM. Study of the utilization of light egg-type males: A proposal for the sustainability of the egg industry. *Poult Sci*. 2014;93(3):755-761.
3. Bruijnjs MRN, Blok V, Stassen EN, Gremmen HGJ. Moral "lock-in" in responsible innovation: the ethical and social aspects of killing day-old chicks and its alternatives. *J Agric Environ Ethics*. 2015;28(5):939-960.
4. Daida K, Ramarao SV, Chinnipreetam V, Reddy VR, Prakash B, Qudratullah S. Improving livelihood security of rural women through Rajasree backyard poultry farming. *Indian J Poult Sci*. 2012;47(2):231-233.
5. Gang FY, Zhen YS. A study on the growth curve of and maximum profit from layer-type cockerel chicks. *Br Poult Sci*. 1997;38(4):445-446.
6. Giersberg MF, Kemper N. Rearing male layer chickens: A German perspective. *Agriculture*. 2018;8(11):176.
7. Huque QME, Mostari MP, Faruque S, Islam MR. Cockerel production: Strategy of family poultry development. Savar, Dhaka: Bangladesh Livestock Research Institute; 2004.
8. Koenig M, Hahn G, Damme K, Schmutz M. Utilization of laying-type cockerels as poussins-growth performance and carcass quality. In: Proceedings of the 19th European Symposium on Quality of Poultry Meat and 13th European Symposium on the Quality of Eggs and Egg Products; 2009 Jun 21-25; Turku, Finland. World's Poultry Science Association; 2009. p. 1-7.
9. Kumar S, Singh PK, Prasad A. Effect of graded level of dietary energy and protein on the growth performance of cockerels. *Indian J Anim Nutr*. 2009;26(1):86-89.
10. Leenstra FR, Munnichs G, Beekman V, van den Heuvel-Vromans E, Aramyan LH, Woelders H. Killing one-day-old male chicks, do we have alternatives? Assessing opinions of the public about alternatives to the killing of one-day-old chickens. In: Conference Knowing Animals: Cross-fertilisation between Natural and Social Sciences for Understanding the Quality of Life of Animals; 2009 Mar 5-6; Florence, Italy. p. 51.
11. Leenstra F, Munnichs G, Beekman V, van den Heuvel-Vromans E, Aramyan L, Woelders H. Killing day-old chicks? Public opinion regarding potential alternatives. *Anim Welf*. 2011;20(1):37.
12. Lichovniková M, Jandásek J, Jůzl M, Dračková E. The meat quality of layer males from free range in comparison with fast growing chickens. *Czech J Anim Sci*. 2009;54(11):490-497.
13. Morris TR, Njuru DM. Protein requirement of fast and slow growing chicks. *Br Poult Sci*. 1990;31(4):803-810.
14. Murawska D, Bochno R. Comparison of the slaughter quality of layer-type cockerels and broiler chickens. *J Poult Sci*. 2007;44(1):105-110.
15. Murawska D, Bochno R, Michalik D, Janiszewska M. Age-related changes in the carcass tissue composition and distribution of meat and fat with skin in carcasses of laying-type cockerels. *Arch Geflügelkd*. 2005;69(3):135-138.
16. Salami RI. Measurement of crude protein requirement of cockerel finishers by two empirical methods. *Ghana J Agric Sci*. 2008;41(2).
17. Salami RI, Akindoye O, Akanni EO. Protein and energy requirements of some cockerel starters in the tropics. *Ghana J Agric Sci*. 2003;36(1):69-77.
18. Salami RI, Longe OG, Oluyemi JA. Effect of dietary protein levels on the performance and carcass characteristics of cockerel finishers. *Niger J Anim Prod*. 2004;31(1):27-31.
19. Soisontes S. An alternative use of one day-old male layer chicks: the case of Thailand. Science and Information Centre for Sustainable Poultry Production (WING); 2015.

20. Subodh. Effect of varied dietary energy and protein levels on the performance of growing cockerels [M.V.Sc. thesis]. Pusa: Rajendra Agricultural University; 2000.
21. Sudhakar J, Ravindra Reddy V, Rao PV, Reddy DN. Studies on comparative economics of sexed broilers and cockerels fed different protein and energy levels. Indian J Poult Sci. 1988;23(2):153-158.
22. Tete A, Tona K, Aklikokou K, Gbeassor M, Buyse J, Decuyper E. Effects of low-protein or high-energy level diets on layer-type chick juvenile performance. Int J Poult Sci. 2010;9(12):1156-1160.
23. Weissmann A, Reitemeier S, Hahn A, Gottschalk J, Einspanier A. Sexing domestic chicken before hatch: A new method for in ovo gender identification. Theriogenology. 2013;80(3):199-205.
24. Yun JG, Kim HR, Oh ST, Zheng L, Choi YI, Choo YK, *et al.* Effects of varying levels of dietary metabolizable energy and crude protein on growth performance and carcass characteristics in layer-type growing male chicks. Korean J Poult Sci. 2012;39(2):87-95.